

SCIENCE ANNEX

OVERVIEW

Science provides the foundation for management actions and policy decisions in support of meeting the objectives of the Agreement.

The 2012 GLWQA recognizes that the effective implementation of management decisions, policies and programs must be based on the best available science, research and knowledge. Throughout the 2012 GLWQA, specific science-based commitments are captured in relation to various Annexes. The Science Annex of the 2012 GLWQA commits the United States and Canada to enhancing the coordination, integration, synthesis, and assessment of science activities across all Annexes of the Agreement.

PROGRESS TOWARD MEETING GLWQA COMMITMENTS

State of the Great Lakes Indicators identified and aligned to the General Objectives of the 2012 GLWQA.

Cooperative Science and Monitoring Initiative (CSMI) rotational cycle and reporting guidelines established.

2016

Draft assessments for Indicators and General Objectives developed.

2015

2013

Science Annex Subcommittee established.

This Annex's implementation is supported by the Science Annex Subcommittee, co-led by the United States Environmental Protection Agency and Environment and Climate Change Canada. Organizations on the subcommittee include: Environment and Climate Change Canada, Fisheries and Oceans Canada, Agriculture and Agri-Food Canada, Natural Resources Canada, Ontario Ministry of Environment and Climate Change, Ontario Ministry of Natural Resources and Forestry, Conservation Ontario, United States Environmental Protection Agency, United States National Oceanic and Atmospheric Administration, United States Army Corps of Engineers, United States Geological Survey, Wisconsin Department of Natural Resources

BINATIONAL ACTIONS TAKEN

Establishing and maintaining comprehensive, science-based ecosystem indicators to assess the state of the Great Lakes, to anticipate emerging threats, and to measure progress in relation to achievement of the Objectives of the Agreement.

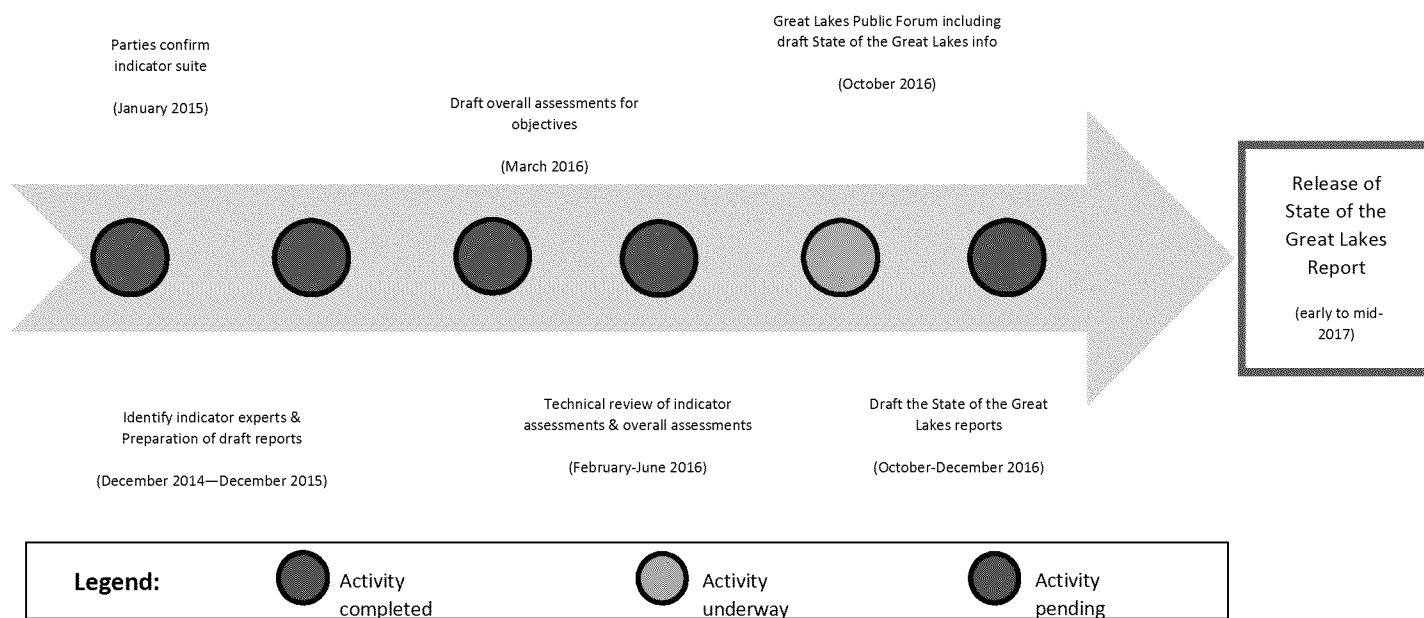
In 2016, issue a State of the Great Lakes Report describing basin-wide environmental trends and lake-specific conditions using ecosystem indicators.

- In January of 2015, the United States and Canada confirmed the suite of indicators to be used to assess water quality and the ecosystem conditions of the Great Lakes under the 2012 GLWQA. This suite of indicators builds on the State of the Lakes Ecosystem Reporting by the Parties, which has been ongoing since 1994.
- The indicator suite includes nine indicators, one for each of the General Objectives of the 2012 GLWQA. The nine indicators are supported by 43 sub-indicators. Figure 14 depicts these indicators and sub-indicators.
- Over 100 Great Lakes experts representing federal, provincial, state and local governments, as well as academia and non-governmental organizations, have engaged in assembling and assessing relevant data, and reporting against the indicator suite.
- In 2016, draft assessments for the indicators were developed and reviewed by subject matter experts. These draft assessment will be presented at the Great Lakes Public Forum in October, 2016 for public comment. A final State of the Great Lakes report, describing basin-wide and lake-specific environmental trends and conditions using the ecosystem indicators, is targeted for release in 2017 (as depicted in Figure 15).

Figure 14 - Indicators and Sub-Indicators for Assessing the State of the Great Lakes.

1.	Drinking Water		
2.	Beaches		
3.	Fish Consumption		
4.	Toxic Chemicals		
•	Toxic Chemical Concentrations (open water)		
•	Toxic Chemicals In Great Lakes Whole Fish		
•	Toxic Chemicals In Great Lakes Herring Gull Eggs		
•	Toxic Chemicals in Sediment		
•	Atmospheric Deposition of Toxic Chemicals		
•	Water Quality in Tributaries		
5.	Habitat & Species		
•	Coastal Wetland	•	Phytoplankton (open water)
•	Invertebrates	•	Zooplankton (open water)
•	Coastal Wetland Fish	•	Benthos (open water)
•	Plants	•	Diporeia (open water)
•	Coastal Wetland	•	Preyfish (open water)
•	Amphibians	•	Lake Trout
•	Birds	•	Walleye
•	Coastal Wetlands: Extent and Composition	•	Lake Sturgeon
•	Aquatic Habitat		
•	Connectivity		
•	Fish Eating and Colonial Nesting Waterbirds		
6.	Nutrients & Algae		
•	Nutrients in Lakes (open water)		
•	Harmful Algal Blooms		
•	Cladophora		
7.	Invasive Species		
•	Aquatic Invasive Species		
•	Sea Lamprey		
•	Dreissenid Mussels		
•	Terrestrial Invasive Species		
8.	Groundwater		
9.	Watershed & Climate Impacts		
•	Water Levels	•	Forest Cover
•	Surface Water	•	Land Cover
•	Temperature		
•	Ice Cover	•	Tributary Flashiness
•	Precipitation Events	•	Hardened Shorelines
•	Baseflow due to Groundwater	•	Human Populations
•	Watershed Stressors		

Figure 15 – State of the Great Lakes Report timeline.



Implementing a cooperative science and monitoring initiative for each of the Great Lakes on a five-year rotational basis.

- The Cooperative Science and Monitoring Initiative (CSMI) was developed under the 1987 GLWQA in order to binationally coordinate the research and monitoring activities being undertaken in the Great Lakes basin (such as coordinating the movement of research vessels like the Lake Guardian and Limnos pictured in Figure 16) and to ensure that the necessary science is efficiently provided to support Great Lakes decision-making and management actions. Each year, as part of the CSMI, U.S. and Canadian organizations assess one of the Great Lakes during that Lake's intensive CSMI field year. This emphasis on one Great Lake per year allows for enhanced coordination of research and monitoring activities, as well as the cooperation on specific science assessments, in that particular Great Lake during that year. This intensive CSMI field year follows a five year rotating cycle (as shown in Figure 17).
- The CSMI process includes the following steps leading up to and following the intensive field year: 1) identification of research and monitoring needs and other science priorities to assess threats to Great Lakes water quality and support management actions; 2) planning, which involves working with governmental and academic scientists to develop and coordinate specific research activities for the Great Lake in question; 3) undertaking the coordinated monitoring and cooperative science assessments (i.e. intensive field year); 4) laboratory analysis; 5) data analysis and reporting; and, 6) final report and communicating out.
- Some examples of lake-specific cooperative science include:
 - An assessment in Lake Ontario, in 2013, of the lower food web and the implementation of projects across federal and state agencies examining nutrient loadings and the nearshore-to-offshore movement of nutrients.
 - An assessment in Lake Erie, in 2014, of Dreissenid mussel populations, nutrient loadings from rivers and western basin sediments, and development of a phosphorus mass balance model for the western and central basin.
 - Addressing nutrient and contaminant loads to Lake Michigan, in 2015, to address contaminants in the lake, and to investigate the movement of nutrients and energy from nearshore to offshore waters.
 - An assessment in Lake Superior, in 2016, of chemical emission reduction actions and an evaluation of the health of the lower food web and important fish communities.

Figure 16 – Research efforts on the Great Lakes.

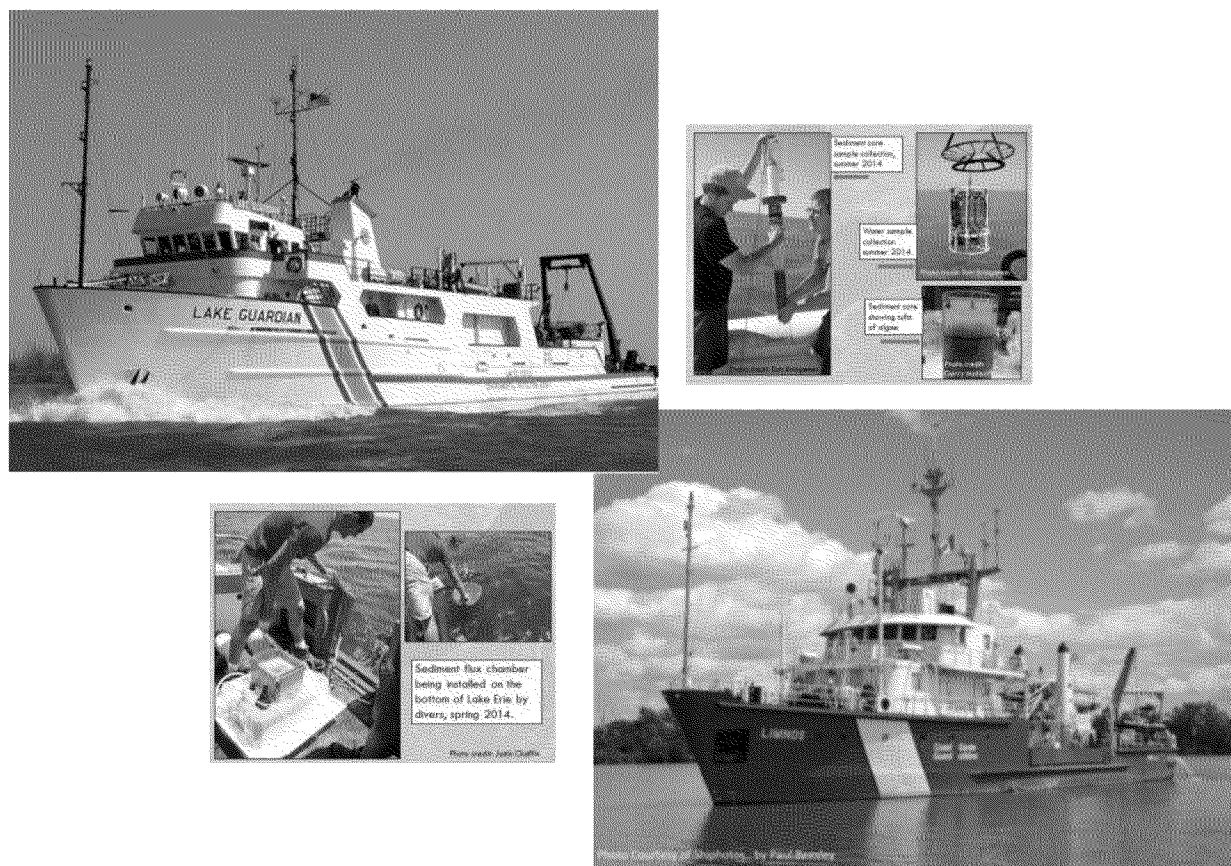
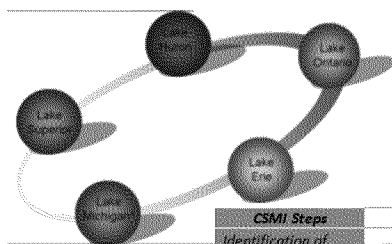


Figure 17 – The Cooperative Science and Monitoring Initiative rotational cycle.



CSMI Steps	2013	2014	2015	2016	2017	2018
<i>Identification of research and monitoring needs and other science priorities</i>	Lake Michigan science needs	Lake Superior science needs	Lake Huron science needs	Lake Ontario science needs	Lake Erie science needs	Lake Michigan science needs
<i>Planning</i>	Lake Erie planning	Lake Michigan planning	Lake Superior planning	Lake Huron planning	Lake Ontario planning	Lake Erie planning
<i>Intensive field year</i>	Lake Ontario field year	Lake Erie field year	Lake Michigan field year	Lake Superior field year	Lake Huron field year	Lake Ontario field year
<i>Laboratory analysis</i>	Lake Huron lab analysis	Lake Ontario lab analysis	Lake Erie lab analysis	Lake Michigan lab analysis	Lake Superior lab analysis	Lake Huron lab analysis
<i>Data analysis and reporting</i>	Lake Superior data analysis	Lake Huron data analysis	Lake Ontario data analysis	Lake Erie data analysis	Lake Michigan data analysis	Lake Superior data analysis
<i>Reporting and communicating out</i>	Lake Michigan report/outreach	Lake Superior report/outreach	Lake Huron report/outreach	Lake Ontario report/outreach	Lake Erie report/outreach	Lake Michigan report/outreach



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Facilitating information management and sharing to improve knowledge, accessibility and exchange of relevant Great Lakes information.

- Data and information management and sharing efforts to support implementation of relevant 2012 GLWQA commitments are being examined. An initial examination was undertaken to understand the data and information management and sharing needs across all of the Annexes of the GLWQA. Based on this information and discussions at the Great Lakes Executive Committee meetings, the Science Annex Subcommittee will be examining existing Great Lakes-related distributed data and information access systems and platforms and their application to a specific pilot project on a priority area such as the Lake Erie phosphorus and/or nearshore issue.

Identifying science priorities, taking into account recommendations of the International Joint Commission.

Undertaking a review of available scientific information to inform management actions and policy development.

- The Science Annex Subcommittee coordinated and assisted in the development of the 2014-2016 binational priorities for science amongst the other Annexes. As called for in Article 5 of the 2012 GLWQA, these priorities, along with the priorities for action, were posted on binational.net (www.binational.net/2014/03/20/psa-pasa-2014) in March 2014.
- In support of the development of nutrient objectives for controlling nuisance *Cladophora* in the Great Lakes, Canada and the United States held a binational workshop on January 28-26, 2016 to determine the state of knowledge of *Cladophora* from the perspectives of the entire Great Lakes basin, from that of individual lakes, and with respect to areas within each lake where *Cladophora* is perceived to be a significant local problem. The findings of the workshop will help guide a strategy for proposing nutrient reduction targets that will control *Cladophora*.

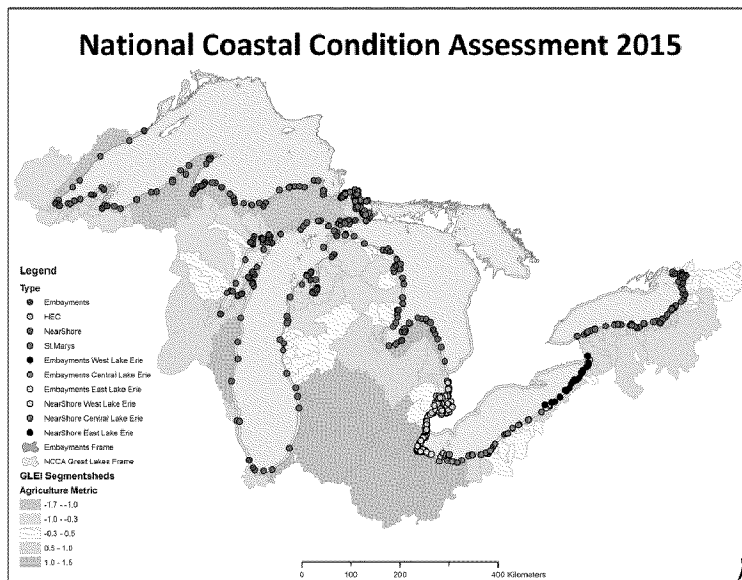
DOMESTIC ACTIONS TAKEN



- Between 2013 and 2016, the United States Environmental Protection Agency's Great Lakes National Program Office used Great Lakes Restoration Initiative (GLRI) funding to maintain and enhance its Long-Term Great Lakes Monitoring Programs. These programs include the Open Lake Water Quality Surveys, the Integrated Atmospheric and Deposition Network, the Great Lakes Fish Monitoring and Surveillance Program.

- Between 2013 and 2016, GLRI funding helped supplement the Environmental Protection Agency's implementation of its Great Lakes National Coastal Condition Assessment. The assessment is undertaken every five years to determine the condition of the nation's coastal waters as well as to evaluate the importance of key stressors such as nutrients and pathogens (as shown in Figure 18). The Great Lakes assessment included monitoring 100 sites per Great Lake, including the connecting channels (Huron-Erie Corridor and St. Marys River).

Figure 18 – United States Environmental Protection Agency's Great Lakes National Coastal Condition Assessment.



- In support of the Nutrient and Lakewide Management Annexes, and with the support of GLRI funding, the Environmental Protection Agency and the United States Geological Survey assessed and better understand the impacts of agriculture and agricultural practices, climate change, and land use change on the timing and magnitude of delivery of nutrients and sediments to the Great Lakes.
- In 2015, the United States National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory partnered with the University of Michigan's Cooperative Institute for Limnology and Ecosystems Research and used GLRI funding to sample eight sites throughout the western basin of Lake Erie and four sites in Lake Huron's Saginaw Bay. The sampling was done to assess the impact of land use on algal bloom development. Measurements of bloom toxicity have proven invaluable to regional stakeholders and the Nutrients Annex Task Team.
- In an effort to build broader research partnerships, the Environmental Protection Agency's Great Lakes National Program Office has made the 180-foot R/V Lake Guardian available to researchers to provide sampling access to the open waters of the Great Lakes.
- With the support of GLRI funding, an initial coastal wetland classification assessment was completed that will be used by the Habitat and Species Annex Subcommittee to prioritize

coastal wetland work.



- The Government of Canada is committed to Open Science and Open Data, which includes performing science in a more open and collaborative manner, and maximizing accessibility to federal publications and data. Through the Action Plan on Open Government, Canada is pledging to expand its open government activities to broaden access to data and information, ensure transparency and accountability, and strengthen citizen engagement in the activities of government and in the democratic process. Data collected by Environment and Climate Change Canada in the Great Lakes to support the implementation of the 2012 GLWQA, is being prepared for release on the Government of Canada's Open Data Portal and datasets are being piloted through the process to validate and ensure future sustainability and openness of the approach.
- The Freshwater Quality Monitoring and Surveillance Program (FWQMS) of Environment and Climate Change Canada conducts water quality surveys of nutrients and contaminants in water, sediment and aquatic biota in the open lakes, tributaries, Areas of Concerns and in the connecting channels. This long-term monitoring program monitors legacy compounds (such as PCBs, PAHs and organochlorine pesticides), and more recently, also includes monitoring of emerging compounds (such as organosiloxanes, brominated and organophosphate flame retardants and Bisphenol A).
- The Environment and Climate Change Canada Chemicals Management Plan (CMP) Monitoring and Surveillance in the Great Lakes Basin (GLB) for air and precipitation monitors for both legacy and emerging compounds (CMP priority substances and others). Combining air (GLB), precipitation (GLB) and water (FWQMS) concentrations of these substances, atmospheric deposition can be estimated. CMP Monitoring and Surveillance also include monitoring of these substances in biota (fish and birds etc.), sediments and waste water treatment plants (biosolids, effluents, etc.). The CMP multi-media monitoring effort advances the understanding of Chemicals of Mutual Concern (CMC) input and pathways in the Great Lakes region. Also, this effort provides essential risk assessment information required for future identification of additional CMCs.
- In 2014, Environment and Climate Change Canada collaborated in a joint study with the Ontario Ministry of the Environment and Climate Change to measure changes in herbicide concentrations in Ontario urban streams (with five of the ten urban streams selected flowing into Lake Ontario) following a cosmetic pesticides ban in 2009. Findings indicate that concentrations in the majority of the study streams decreased significantly following the cosmetic pesticides ban, decreasing from 16% to 92%, depending on the stream and herbicide.
- As part of Great Lakes Nutrient Initiative, Environment and Climate Change Canada supported the development and implementation of binational phosphorous load targets in Lake Erie by conducting intensive open lake, nearshore and tributary monitoring; and modelling and research

on nuisance and harmful algal blooms.

- Environment and Climate Change Canada is also conducting nutrient loading research in Georgian Bay to identify adverse impacts such as the generation of harmful algal blooms and hypoxia in some nearshore regions.
- In March 2013, a Canadian workshop was organized to support identifying possible science priorities that Canada could put forward for first three years under the 2012 GLWQA, pursuant to the development of the binational priorities for science called for in Article 5 of the 2012 GLWQA.
- Within Environment and Climate Change Canada, two Great Lakes Science Days have been held in an effort to share information on priorities, progress and emerging issues, and also to encourage continued collaboration between Great Lakes scientists, researchers and program teams within the department.